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COMPUTER SCIENCE

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SOFTWARE SYSTEM REQUIREMENTS FOR THE ARMY TACTICAL MISSILE SYSTEM (ATACMS) END-TO-END SYSTEM USING THE COMPUTER AIDED PROTOTYPING SYSTEM(CAPS) MULTI-FILE APPROACH
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The Department of Defense (DoD) is seeking software system requirements for the Army Tactical Missile System (ATACMS) End-to-End System, which comprises both ATACMS and all sensors, links, and command centers which enable integration across system and service boundaries. The complexity, multiple interfaces, and joint nature of planned ATACMS operations demands accurate specification of software system requirements. DoD also desires automated tools capable of developing rapid prototypes to assist in system definition and reduce system risk.

The goals of this thesis are to provide a rigorous model which can be utilized to validate current specifications, and, to demonstrate CAPS on a large scale project. Accomplishment of these two would provide a needed corroboration of the ATACMS specification, as well as move CAPS out of the purely academic environment.

The result of this thesis is mixed. Due to a paucity of data from which to derive the requirements, the model is generic in nature and is in need of significant customer evaluation, which is not forthcoming. However, CAPS demonstrated its fundamental concept within the bounds of the project, with refinements in code generation, interface, and graphics either incorporated or identified. CAPS is ready for use on an actual project by an experienced team of systems analysts.

THE DESIGN AND IMPLEMENTATION OF A COMPILER FOR THE OBJECT-ORIENTED DATA MANIPULATION LANGUAGE
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Object-oriented relationships, such as inheritance and covering can not be readily incorporated in classic data models. This thesis addresses this problem by the design and implementation of an object-oriented data model (O-ODM), that incorporates the object-oriented paradigm.

A Multimodel and Multilingual Database System called M^2DBS has been developed at the Naval Postgraduate School. This system incorporates the classic database data models along with a recently developed object-oriented data model (O-ODM). The problem addressed by this work is to design a new object-oriented data manipulation language (O-ODML) for the O-ODM. The approach is to develop and construct an O-ODML Compiler. Then assimilate the compiler with the Kernel Mapping System (KMS) of the M^2DBS.

The result of this thesis is a compiler for the O-ODML of the O-ODM. This O-ODML compiler takes an O-ODM query converts it into a low level intermediate language before translating it into a format that the Real Time Monitor can execute on the M²DBS.

HEADPHONE-DELIVERED THREE DIMENSIONAL SOUND IN NPSNET
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The current MIDI-based sound system for the distributed virtual environment of NPSNET can only generate aural cues via loudspeaker delivery in two dimensions. To further increase the sense of immersion experienced in NPSNET, a sound system is needed which can generate aural cues via headphone delivery in three dimensions.

The approach taken was to explore the different feasible methods of rendering and presenting headphone-delivered spatial sound. One alternative was to implement a sound server capable of the real-time rendering of three dimensional sounds. Another alternative was to create a library of pre-recorded positioned sound files. In software, new algorithms were developed to integrate the sound server into NPSNET and to provide a table lookup capability for NPSNET's new spatial sound file library.

The result of this research is a sound server capable of rendering up to twenty-four simultaneous sounds for a single participant in NPSNET using "off-the-shelf" sound equipment and computer software. This sound server was tested during numerous demonstrations of NPSNET. This research provided another method of increasing a participant's level of immersion in NPSNET through the use of aural cues.

PORTING HIGH QUALITY GRAPHICS SIMULATIONS
TO A LOW-COST COMPUTER ARCHITECTURE
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B.S., United States Naval Academy, 1989
Master of Science in Computer Science-September 1996
and
Frank Free-Major, United States Marine Corps
B.S., United States Naval Academy, 1983
Master of Science in Computer Science-September 1996
Advisors: David R. Pratt, Department of Computer Science
John S. Falby, Department of Computer Science

Two disadvantages of using Silicon Graphics®, Inc. (SGI) computers and SGI's IRIS® Performer™ application programming interface (API) in NPSNET are the current inability to run the graphic simulations on more popular environments, such as personal computer (PC) operating systems (OSs), and the increased expense associated with the alternative of choosing graphics specific hardware over lower cost PCs. Work detailed in this thesis addresses these problems by porting graphics code from NPSNET to relatively inexpensive PC hardware running the Microsoft® Windows NT™ OS.

Two independent approaches were taken. The first created a library of graphics calls which simulate the syntax and functionality of Performer calls, but which have been redefined in terms of the Gemini Technology Corporation's OpenGVS™ API, which is capable of running on the NT platform. The second proposed and implemented a prototype graphics display manager coded using only OpenGVS, rather than Performer, for a proposed platform-independent redesign of NPSNET.

As a result of this effort, the goal of porting IRIS Performer graphics simulations to the PC has been accomplished, and a new architecture for NPSNET display managers has been validated.

MERGING VIRTUAL AND REAL EXECUTION LEVEL CONTROL SOFTWARE FOR THE PHOENIX AUTONOMOUS UNDERWATER VEHICLE
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Master of Science in Computer Science-September 1996
Advisors: Robert B. McGhee, Department of Computer Science
Don Brutzman, Undersea Warfare Academic Group

The Naval Postgraduate School (NPS) is developing an AUV, Phoenix. The Phoenix has the capability of precise navigation, however too much time is needed to validate a new section of code. NPS is also developing a virtual AUV, which has the capability of being networked, having flexible missions, and having a quick feedback of results when validating new portions of code. The virtual AUV has a drawback of never being tested for real world precision. This thesis discusses the steps taken to combine these two sets of control code to obtain the maximum functionality that will drive either the virtual or actual AUV and produce a faster feedback response to newly developed code.

As a result of this effort, the newly developed control code has successfully driven both the actual and virtual AUVs and provides a means for readily validating new code. Also this new control code has given the AUV research group the ability to perform distributed software development, test all AUV hardware from either the onboard or offboard computers, conduct flexible missions, and test missions in the virtual world prior to conducting them with the AUV.

IMPLEMENTATION AND EFFICIENCY OF STEGANOGRAPHIC TECHNIQUES IN BITMAPPED IMAGES AND EMBEDDED DATA SURVIVABILITY AGAINST LOSSY COMPRESSION SCHEMES
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B.S., Vanderbilt University, 1991
Master of Science in Computer Science-March 1996
and
Daniel L. Currie III-Lieutenant, United States Navy
B.S., West Virginia Institute of Technology, 1987
Master of Science in Computer Science-March 1996
Advisors: Cynthia E. Irvine, Department of Computer Science
Harold Fredricksen, Department of Mathematics

The term steganography is descriptive of techniques used to covertly communicate by embedding a secret message within an overt message. Such techniques can be used to hide data within digital images with little or no visible change in the perceived appearance of the image and can be exploited to covertly export sensitive information. This thesis explores the data capacity of bitmapped image files and the feasibility of devising a coding technique which can protect embedded data from the deleterious effects of lossy compression.

In its simplest form, steganography in images is accomplished by replacing the least significant bits of the pixel bytes with the data to be embedded. Since images are frequently compressed for storage or transmission, it is desirable that a steganographic technique include some form of redundancy coding to counter the errors caused by lossy compression algorithms. Specifically, the Joint Photographic Expert Group (JPEG) compression algorithm, while producing only a small amount of visual distortion, introduces a relatively large number of errors in the bitmap data. These errors will effectively garble any non-coded steganographically embedded data.

This thesis shows that, although there are numerous protocols for embedding data within pixels, the limiting factor is always the number of bits modified in each pixel. A balance must be found between the amount of data embedded and the amount of acceptable distortion. This thesis also demonstrates that, despite errors caused by compression, information can be encoded into pixel data so that it is recoverable after JPEG processing, though not with perfect accuracy.

REAL-TIME SONAR CLASSIFICATION FOR AUTONOMOUS UNDERWATER VEHICLES
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Master of Science in Electrical Engineering-March 1996
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Xiaoping Yun, Department of Electrical and Computer Engineering

The Naval Postgraduate School autonomous underwater vehicle (AUV) Phoenix did not have any sonar classification capabilities and only a basic collision avoidance system. The Phoenix also did not have the capability of dynamically representing its environment for path planning purposes.

This thesis creates a sonar module that handles real-time object classification and enables collision avoidance at the Tactical level. The sonar module developed communicates directly with the available sonar and preprocesses raw data to a range/ bearing data pair. The module then processes the range/bearing data using parametric regression to form line segments. A polyhedron-building algorithm combines line segments to form objects and classifies them based on their attributes. When the Phoenix is transiting, the classifying algorithm detects collision threats and initiates collision avoidance procedures.

The result of this thesis is a fully implemented sonar module on the Phoenix. This module was tested in a virtual world, test tank and in the first ever sea-water testing of the Phoenix. The sonar module has demonstrated real-time sonar classification, run-time collision avoidance and the ability to dynamically update the representation of the unknown environment. The sonar module is a forked process written in the "C" language, functioning at the Tactical level. Source code and output from an actual Phoenix mission displaying the object classification of the sonar module are included.

GEOLOCATION WORKBENCH
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Master of Science in Computer Science-December 1995
Advisors: Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering
Timothy J. Shimeall, Department of Computer Science

This thesis defines software requirements for a geolocation workbench software environment. A geolocation workbench is a tool that studies the algorithms that provide the location of an active transmitter using techniques such as Time Difference of Arrival (TDOA) or Frequency Difference of Arrival (FDOA). The study would involve efficiency of calculation, accuracy of results and sensitivity to error.

The approach taken was the development of a rapid prototype of the Geolocation Workbench. The prototype implements the Geolocation Workbench system user interface and is evaluated by the customer, Professor Loomis of the Department of Electrical and Computer Engineering, Naval Postgraduate School, to refine the requirements. The requirements call for measuring TDOA, FDOA and emitter motion errors.

The results were as follows: After three prototype demonstrations and six one hour meetings a total of 50 screen panels were created with the desired functionality described in each panel. The functions included having the ability to enter text, display graphics, make file selections and edit data.

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DIPHONE-BASED SPEECH RECOGNITION USING NEURAL NETWORKS

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Master of Science in Computer Science-June 1996
Master of Science in Systems Technology-June 1996
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Speaker-independent automatic speech recognition (ASR) is a problem of long-standing interest to the Department of Defense. Unfortunately, existing systems are still too limited in capability for many military purposes. Most large-vocabulary systems use phonemes (individual speech sounds, including vowels and consonants) as recognition units. This research explores the use of diphones (pairings of phonemes) as recognition units. Diphones are acoustically easier to recognize because coarticulation effects between the diphone's phonemes become recognition features, rather than confounding variables as in phoneme recognition. Also, diphones carry more information than phonemes, giving the lexical analyzer two chances to detect every phoneme in the word. Research results confirm these theoretical advantages. In testing with 4490 speech samples from 163 speakers, 70.2% of 157 test diphones were correctly identified by one trained neural network. In the same tests, the correct diphone was one of the top three outputs 89.0% of the time. During word recognition tests, the correct word was detected 85% of the time in continuous speech. Of those detections, the correct diphone was ranked first 41.6% of the time and among the top six 74% of the time. In addition, new methods of pitch-based frequency normalization and network feedback-based time alignment are introduced. Both of these techniques improved recognition accuracy on male and female speech samples from all eight dialect regions in the U.S. In one test set, frequency normalization reduced errors by 34%. Similarly, feedback-based time alignment reduced another network's test set errors from 32.8% to 11.0%.

DESIGN AND ANALYSIS OF AN OBJECT-ORIENTED DATABASE OF ELECTRONIC WARFARE DATA

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Advisors: David K. Hsiao, Department of Computer Science
C. Thomas Wu, Department of Computer Science

The Electronic Warfare Integrated Reprogramming Database (EWIRDB) is the primary Department of Defense (DoD) approved source of electronic warfare (EW) data. Its utilization in the areas of battle planning and EW research enables our military forces to effectively exploit the electromagnetic spectrum and shape the outcome of battle. The EWIRDB, however, lacks a viable conceptual data model. EWIRDB data are represented in disjoint parametric tree models that are implementation-oriented; to the extent that the tree structures are used as conceptual modeling tools, their hierarchical form is too restrictive to adequately describe EW data semantics. Moreover, these structures address only technical parametric data. Associated administrative, reference, and comment data are excluded. In practice, the EWIRDB is described in terms of the coded and record-based format of its output media, not its conceptual model.

The primary goal of this thesis is the development of a semantically-improved conceptual design of EWIRDB data based on the object-oriented data model (OODM). The secondary goal of the thesis is the specification of a logical design, based on the new conceptual design, to provide the structure for a subsequent implementation of EWIRDB data on the Multimodel and Multilingual Database System (M²DBS) in the Laboratory for Database Systems Research at the Naval Postgraduate School.

The results of the work contained herein are: (1) an object-oriented conceptual design of EWIRDB data that supports the semantics of both the file format and tree structures, and (2) the specification of an object-oriented logical design for an M²DBS implementation of sample EWIRDB data.

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INTERNETWORKING: THE INTEROPERABILITY OF COMMERCIAL MOBILE COMPUTERS WITH THE USMC DIGITAL AUTOMATED COMMUNICATIONS TERMINAL (DACT)

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Advisor: Don Brutzman, Undersea Warfare Academic Group
Second Reader: Lou Stevens, Department of Computer Science

The United States Marine Corps has begun to develop a system called the Digital Automated Communications Terminal (DACT). The DACT system is based around a subnotebook-sized, tactical input/output battlefield situational awareness system and communications terminal. The problem is that DACT's excessive weight, size, cost and complexity might ultimately prevent its successful integration into the rapidly evolving Marine Corps style of maneuver warfare.

This thesis provides a study of palmtop-sized mobile computing platforms to include the Hewlett-Packard family of palmtops, as well as the emerging Microsoft® Pegasus mobile operating system. Furthermore, various messaging standards, protocols and commercial digital transmission channels are analyzed for their suitability to DACT requirements. Finally, a system prototype called the "Rapid Electronic Delivery of Messages over Asynchronous Networks" (REDMAN) is implemented to disseminate field orders under combat conditions. REDMAN speeds the flow of accurate information to all levels of command within a Marine infantry battalion using a commercial palmtop platform. This commercial palmtop is 3-7 times lighter and 20-30 times less expensive than DACT. Wireless networked palmtop computing will completely change the scope of Marine warfighting. This thesis provides a proof of concept system that demonstrates such fundamental change is feasible today.

IMPLEMENTATION AND EFFICIENCY OF STEGANOGRAPHIC TECHNIQUES IN BITMAPPED IMAGES AND EMBEDDED DATA SURVIVABILITY AGAINST LOSSY COMPRESSION SCHEMES

Daniel L. Currie III-Lieutenant, United States Navy
B.S., West Virginia Institute of Technology, 1987
Master of Science in Computer Science-March 1996
and
Hannelore Campbell-Lieutenant, United States Navy
B.S., Vanderbilt University, 1991
Master of Science in Computer Science-March 1996
Advisors: Cynthia E. Irvine, Department of Computer Science
Harold Fredricksen, Department of Mathematics

The term steganography is descriptive of techniques used to covertly communicate by embedding a secret message within an overt message. Such techniques can be used to hide data within digital images with little or no visible change in the perceived appearance of the image and can be exploited to covertly export sensitive information. This thesis explores the data capacity of bitmapped image files and the feasibility of devising a coding technique which can protect embedded data from the deleterious effects of lossy compression.

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compression, information can be encoded into pixel data so that it is recoverable after JPEG processing, though not with perfect accuracy.

NPSNET VEHICLE DATABASE: AN OBJECT-ORIENTED DATABASE IN A REAL-TIME VEHICLE SIMULATION
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Advisors: Michael J. Zyda, Department of Computer Science
David R. Pratt, Department of Computer Science

The Naval Postgraduate School has actively explored the design and implementation of NPSNET, a real-time three-dimensional simulator on low-cost, readily accessible workstations. NPSNET involves a tremendous amount of interaction between vehicle, terrain, obstacle and ordnance objects in a dynamic simulation system. There exists a need for an organized, efficient storage structure that allows real-time retrieval of objects and their interactive relationships.

This work concentrates on selection and design of a vehicle database model to maximize storage and real-time retrieval of data for the NPSNET visual simulator. The results of this effort can be applied to the overall system, NPSNET, in a distributed database management system.

PRECISION CONTROL AND MANEUVERING OF THE PHOENIX AUTONOMOUS UNDERWATER VEHICLE (AUV) FOR ENTERING A RECOVERY TUBE
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Donald Brutzman, Undersea Warfare Academic Group

Because of range limitations imposed by speed and power supplies, covert launch and recovery of Autonomous Underwater Vehicles (AUVs) near the operating area will be required for their use in many military applications. This thesis documents the implementation of precision control and planning facilities on the *Phoenix* AUV that will be required to support recovery in a small tube and provides a preliminary study of issues involved with AUV recovery by submarines.

Implementation involves the development of low-level behaviors for sonar and vehicle control, mid-level tactics for recovery planning, and a mission-planning system for translating high-level goals into an executable mission. Sonar behaviors consist of modes for locating and tracking objects, while vehicle control behaviors include the ability to drive to and maintain a position relative to a tracked object. Finally, a mission-planning system allowing graphical specification of mission objectives and recovery parameters is implemented.

Results of underwater virtual world and in-water testing show that precise AUV control based on sonar data can be implemented to an accuracy of less than six inches and that this degree of precision is sufficient for use by higher-level tactics to plan and control recovery. Additionally, the mission-planning expert system has been shown to reduce mission planning time by approximately two thirds and results in missions with fewer logical and programming errors than manually generated missions.

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IMPLEMENTING VOICE RECOGNITION AND NATURAL LANGUAGE PROCESSING IN THE NPSNET NETWORKED VIRTUAL ENVIRONMENT

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John Falby, Department of Computer Science

Interfaces to military Virtual Reality (VR) systems, such as NPSNET IV.9, have been limited mainly to keyboard, mouse, and joystick devices. This presents two major problems; remembering how to access all the functionality of the system, and using the interface when the user is otherwise physically constrained. This can occur during the use of body-position tracking devices and Heads-Up-Displays (HUD). Voice recognition and Natural Language Processing (NLP) were used as a solution to both problems.

The approach taken was to develop a networked Spoken Language System (SLS) using a Commercial-Off-The-Shelf (COTS) voice recognition and NLP system. The Nuance Speech Recognition System from Nuance Communications was chosen after analyzing the special requirements of NPSNET. Implementing the SLS occurred in four phases. First, vocabularies and grammars were developed to simulate the 108 keyboard commands, focusing on flexibility and decreased response latency. Second, new C++ classes were written to ease reuse of the Nuance API's. Third, a control panel was written to manage the voice processing, and fourth, the code was integrated into NPSNET.

As a result of this effort, a new voice-enabled interface exists for NPSNET. In addition, C++ classes exist to ease future use of the Nuance API in other software systems. All of the 108 keyboard commands are executable through voice control with a 83.8% sentence understanding rate in a noisy background environment.

THE ACTIVATION AND TESTING OF THE NETWORK CODASYL-DML INTERFACE OF THE M²DBMS USING THE EWIR DATABASE

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and
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Second Reader: David K. Hsiao, Department of Computer Science

The Electronic Warfare Integrated Reprogramming Database (EWIRDB) is the primary Department of Defense source for technical parametric performance data on noncommunications emitters. A problem of the EWIRDB is that the data are represented in disjoint parametric tree models that are implementation oriented. The parametric tree with its deceptive hierarchical structure, provides a poor modeling construct that obscures the intended semantics and representation of the data, thus making the database difficult to use and understand from a users perspective. The problem addressed by this thesis is to determine if the network model and the network interface of the Multi-Lingual, Multi-Model Database Management System (M²DBMS) in the Laboratory for Database Systems Research at the Naval Postgraduate School is capable of supporting a representative subset of the EWIRDB.

The primary goal of this thesis is to implement a representative portion of the EWIR database on the network interface of the M²DBMS. In order to accomplish this goal, the following issues must be addressed: First, the network interface must be activated and returned to its original operational state; second, the network interface must be tested to determine its capabilities and limitations; and last, the design and specification of a network EWIR data model must be completed prior to its implementation.

We successfully reactivated the network interface to its original operational state. However, testing revealed significant limitations of the network interface. Due to these limitations, only the data definition portion of our proposed design was fully implemented.

INTERNETWORKING: AUTOMATED LOCAL AND GLOBAL NETWORK MONITORING
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Master of Science in Computer Science-September 1996
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Second Reader: Lou Stevens, Department of Computer Science

Commercial applications for network monitoring are expensive and therefore not widely available to the majority of network users. Public domain network monitoring software is generally effective in the hands of an expert but difficult to use by the common user because of its command line driven interface. It is a basic tenet of this thesis that network performance and security can be improved if all network users had easy-to-use network monitoring tools available and were encouraged to use them frequently. In this thesis, *ping, traceroute,* and *nslookup* were integrated with the familiar user-friendly interface provided by the World Wide Web (WWW) and HyperText Markup Language (HTML) in both automated and interactive versions. These easy to use monitoring tools were evaluated in several working environments at the Naval Postgraduate School and the Monterey Bay Area Network. *ping, traceroute* and *nslookup* can now be performed in one-sixth of the time previously required for an expert user. Current network status is now readily available and can be validated at any time through the use of the applications developed in this thesis.

REACTIVATION OF THE RELATIONAL INTERFACE IN M²DBMS
AND IMPLEMENTATION OF THE EWIR DATABASE
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Master of Science in Computer Science-September 1996
and
Donna N. Scrivener-Lieutenant Commander, United States Navy
B.A., State University of New York, 1981
Master of Science in Computer Science-June 1996
Advisor: C. Thomas Wu, Department of Computer Science
Second Reader: David K. Hsiao, Department of Computer Science

The primary Department of Defense source for technical parametric performance data on non-communications emitters is the Electronic Warfare Reprogramming Database (EWIRDB). Data representation in the EWIRDB is via disjointed parametric tree models which are implementation oriented. These parametric trees obscure the intended semantics and representation of the data, making the database difficult to use and understand. The problem addressed by this thesis is to determine if the relational model and the relational interface of the Multimodel and Multilingual Database System (M²DBMS) in the Laboratory for Database Systems Research at the Naval Postgraduate School is capable of supporting a representative subset of the EWIRDB.

We implemented a representative portion of the EWIR database on the relational interface of the M²DBMS. In order to accomplish this the relational interface was reactivated and returned to its original operational state and fully tested to determine its capabilities. In addition, the schema and an instance of a relational EWIR data model must be developed for implementation.

The relational interface was successfully returned to its original operational state. Significant limitations in the interface's ability to process queries were discovered, however, in that the system can not query schema of greater than four relations.

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INTERNETWORKING: IMPLEMENTATION OF MULTICASTING
AND MBONE OVER FRAME RELAY NETWORKS

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Michael Zyda, Department of Computer Science

The major problems addressed by this thesis research are how to implement multicast over the Monterey BayNet to enable live audio/video for distance learning, how to safely integrate regional Frame Relay multicast with the global MBone, and how to monitor multicast connectivity over the Monterey BayNet.

To implement multicast and MBone over the Monterey BayNet without using dedicated multicast servers, we enabled Protocol Independent Multicast (PIM) protocol on already-installed Frame-Relay-capable routers. By implementing multicast over Monterey BayNet, we show that the current MBone software provides the same performance that it provides on regular Internet connections even on low-speed (128Kbps) Frame Relay network connections and low-cost personal computers. In order to control the scope of the regional multicast and to safely integrate regional Frame Relay multicast with the global MBone, we used administratively controlled multicast group address (224.0.1.20) in addition to the use of time-to-live (TTL) control mechanism. This eliminates global duplication of multicast packet delivery.

Public-domain multicast monitoring tools are used to monitor the multicast connectivity through internetworks. Since these tools are available only to UNIX-based platforms, they cannot be used by the regional sites that mostly have Windows and Macintosh platforms. We developed Web-accessible multicast monitoring pages in order to meet the multicast monitoring needs of the regional sites. Participating sites are now able to monitor regional multicast connectivity by accessing these pages, which permits remote problem diagnosis. That was previously impossible. Finally we synopsize firewall requirements for secure and effective use of multicast.

PORTING HIGH QUALITY GRAPHICS SIMULATIONS
TO A LOW-COST COMPUTER ARCHITECTURE

Frank Free-Major, United States Marine Corps
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Master of Science in Computer Science-September 1996
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Advisors: David R. Pratt, Department of Computer Science
John S. Falby, Department of Computer Science

Two disadvantages of using Silicon Graphics®, Inc. (SGI) computers and SGI's IRIS}3 Performer™ application programming interface (API) in NPSNET are the current inability to run the graphic simulations on more popular environments, such as personal computer (PC) operating systems (OSs), and the increased expense associated with the alternative of choosing graphics specific hardware over lower cost PCs. Work detailed in this thesis addresses these problems by porting graphics code from NPSNET to relatively inexpensive PC hardware running the Microsoft® Windows NT™ OS.

Two independent approaches were taken. The first created a library of graphics calls which simulate the syntax and functionality of Performer calls, but which have been redefined in terms of the Gemini Technology Corporation's OpenGVS™ API, which is capable of running on the NT platform. The second proposed and implemented a prototype graphics display manager coded using only OpenGVS, rather than Performer, for a proposed platform-independent redesign of NPSNET.

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As a result of this effort, the goal of porting IRIS Performer graphics simulations to the PC has been accomplished, and a new architecture for NPSNET display managers has been validated.

APPLICATION OF INERTIAL SENSORS AND FLUX-GATE MAGNETOMETER
TO REAL-TIME HUMAN BODY MOTION CAPTURE

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Master of Science in Computer Science-September 1996
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Michael Zyda, Department of Computer Science
Second Reader: Russ Whalen, Department of Computer Science

Human body tracking for synthetic environment interface has become a significant human-computer interface challenge. There are several different types of motion capture systems currently available. Inherent problems, most resulting from the use of artificially-generated source signals, plague these systems. A proposed motion capture system is being developed at the Naval Postgraduate School which utilizes a combination of inertial sensors to overcome these difficulties. However, the current design exhibits azimuth drift errors resulting from the use of inertial sensors.

This thesis proposes a new method of compensating for azimuth drift using a three-axis fluxgate magnetometer. The fluxgate magnetometer is capable of azimuth drift compensation since its sensitive axis is not collinear with the local vertical. This thesis includes a program for simulating the operation of a fluxgate magnetometer in C++. The included C++ code simulates a fluxgate magnetometer and provides an estimate of azimuth based on the magnetometer's output which is typically within five degrees of the actual azimuth. Real magnetometer data for testing and verification was accomplished by bench testing a real fluxgate magnetometer.

A NATIONAL IMAGERY SYSTEMS SECURITY POLICY

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Master of Science in Computer Science-March 1996
Advisor: Cynthia E. Irvine, Department of Computer Science

The Central Imagery Office (CIO) has no Information Systems Security Policy (ISSP). Therefore, this thesis: 1) outlines the CIO's mission, 2) identifies the necessary elements of an ISSP, 3) summarizes the accreditation process, 4) proposes a new network view—the Feudal view, 5) reviews higher level ISSP guidance, then 6) proposes a National ISSP to guide the CIO in its role of accrediting systems and networks under its purview in a multi-accreditor environment. The policy specifies the following minimum security requirements: confidentiality, integrity, availability, authenticity, and accountability; for both individual systems and networks. The thesis promotes a risk management approach by indicating that lesser constraints can be invoked for systems that are not considered "critical sources" for imagery. The Feudal network view would permit systems to exchange sensitive and classified data over open/public networks provided that they: 1) incorporate an NSA approved trusted front end, 2) communicate via NSA approved cryptographic mechanisms, and 3) follow a defined set of information transfer rules. One such set of rules are presented, and are intended to both: enforce the DoD access policy, and preclude the "cascade" and "propagation of risk" vulnerabilities discussed in the National Computer Security Center's *Trusted Network Interpretation.*

MASTER OF SCIENCE IN COMPUTER SCIENCE

THE DEVELOPMENT OF A RELATIONAL DATABASE TO SUPPORT THE
FLIGHT HOUR PROGRAM OF COMMANDER, NAVAL AIR FORCES PACIFIC

Mark J. Gonzalez-Commander, United States Navy
B.S., United States Naval Academy, 1980
Master of Science in Computer Science-September 1996
and
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Master of Science in Computer Science-June 1996
Advisors: C. Thomas Wu, Department of Computer Science
John Falby, Department of Computer Science

The Air Forces Pacific Financial Analysis Tool (AFAST) has been described by senior leadership within the Air Forces Pacific (AIRPAC) staff as inaccurate, marginally satisfactory and too small in scope to produce output in a relevant and timely manner. Moreover, improvements to the current database are time consuming and cost prohibitive; the absence of adequate design documentation prohibits major modification of the database without significant investment of the limited resources possessed by AIRPAC.

The primary goal of this thesis is the development of an improved conceptual design of the AFAST database based on the enhanced entity-relationship model concepts. The secondary goals of the thesis are the specification of the logical design of the improved database, and the implementation of AFAST II, a prototype application of the redesigned database.

The results of this thesis are: (1) an enhanced entity-relationship model that fully meets the design goals of Naval Air Forces Pacific, (2) the specification of the logical design for the implementation of the redesigned database, and (3) the development of a prototype application validating the conceptual and logical designs.

ENHANCEMENTS FOR THE CAPS PROTOTYPING SYSTEM DESCRIPTION
LANGUAGE SYNTAX-DIRECTED EDITOR

Scott Robert Grosenheider-Captain, United States Marine Corps
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CAPS (Computer-Aided Prototyping System) is an integrated set of software tools that generate source programs directly from real-time requirements. CAPS users can specify the requirements of prototypes as augmented computational graphs using the graphics/text editor. The problem with the current version of CAPS is that most of the feasibility checks for the prototypes are currently enforced by the translator and the scheduler. Such an approach requires the engineers to go through the "edit, save file, then translate and schedule" cycle in order to find out if the control and timing constraints can be satisfied.

The prototyping process can be made much more efficient and user-friendly if these checks are enforced by the CAPS PSDL (Prototype System Description Language) SDE (syntax-directed editor), where users can detect and receive warnings as they enter the design. This thesis focuses on the properties that must exist between processes and their inter-connected data flows in order for a prototype to be correct. It further modifies the PSDL SDE so that parts of the prototype are captured, combined, and manipulated in a way that provides the semantic information needed to determine if these properties have been violated.

The new editor has been applied to several prototype examples. The results showed that, by catching errors during the editing phase, the user saves time, is better able to stay focused on the design, and is subsequently more productive.

MASTER OF SCIENCE IN COMPUTER SCIENCE

THE DEVELOPMENT OF A RELATIONAL DATABASE TO SUPPORT THE FLIGHT HOUR PROGRAM OF COMMANDER, NAVAL AIR FORCES PACIFIC

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Mark J. Gonzalez-Commander, United States Navy
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John Falby, Department of Computer Science

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The primary goal of this thesis is the development of an improved conceptual design of the AFAST database based on the enhanced entity-relationship model concepts. The secondary goals of the thesis are the specification of the logical design of the improved database, and the implementation of AFAST II, a prototype application of the redesigned database.

The results of this thesis are: (1) an enhanced entity-relationship model that fully meets the design goals of Naval Air Forces Pacific, (2) the specification of the logical design for the implementation of the redesigned database, and (3) the development of a prototype application validating the conceptual and logical designs.

USER INTERFACE AND DATABASE DESIGN FOR SOFTWARE DATABASE OF THE COMPUTER-AIDED PROTOTYPING SYSTEM (CAPS)

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CAPS (Computer-Aided Prototyping System) is an integrated set of software tools that generate prototypes directly from real-time requirements. The success of CAPS depends on being able to generate the prototype quickly so that it can be evaluated, leading to the construction of a program built on true requirements thereby resulting in a better software product. The key to developing prototypes quickly is having a significant software base to choose reusable components from. The problem with the current version of CAPS is that there exists no software base storage facility.

This thesis utilizes the ONTOS database to build the object oriented conceptual design for the data object repository and uses TAE to create the graphical user interface to access the repository. It further explores various searching techniques to determine the best possible implementation of the repository search engine.

The results of this thesis are a conceptual design that can be used to implement the software base and an interface which provides a fluid, intuitive, interactive environment in which the user will be able to manipulate the database when actually built. It further identifies the multi-level filtering technique as the best candidate for searching the database, because of its high recall, high precision, and reduced search time.

MASTER OF SCIENCE IN COMPUTER SCIENCE

RE-ENGINEERING OF THE COMPUTER-AIDED PROTOTYPING SYSTEM FOR PORTABILITY

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Master of Science in Computer Science-September 1996
Advisors: Luqi, Department of Computer Science
Valdis Berzins, Department of Computer Science

The Computer-Aided Prototyping System (CAPS) Release 1 currently runs only on SPARC workstations running SunOS version 4.1.3. This limits the usefulness of CAPS, particularly since Sun has announced it has no plans to continue support for SunOS version 4.x. A solution to this problem is to increase the portability of CAPS by first porting CAPS to the Solaris 2.5 operating system.

Towards this end, this thesis discusses and evaluates the underlying system software and software tools necessary to build and run CAPS within the Solaris 2.5 operating environment for SPARC workstations.

As a result of this effort, a version of CAPS has been created that runs on a SPARC workstations using the Solaris 2.5 operating system. Furthermore, the research has identified the necessary software tools and potential problem areas for determining the feasibility of porting CAPS to other platforms. Versions of X Windows, Motif, Synthesizer Generator, Eli, TAE Plus, and the VADSself Ada compiler are required. Since TAE Plus only supports the SunAda (VADS) compiler, use of a different Ada compiler will require either porting the TAE Ada bindings or using an alternative to TAE Plus. Additionally, an explicit installation of Motif is required to provide all the libraries needed to produce static builds of the CAPS components.

GEOLOCATION WORKBENCH DEVELOPMENT SYSTEM

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This thesis provides a common signal abstraction for the geolocation workbench. The geolocation workbench is a software tool used to develop, modify and test geolocation algorithms. Electronic signals come from a variety of sources, in many different formats and with different descriptive parameters. This has been a hindrance to the development of geolocation and signal processing algorithms.

The approach taken was to examine existing signal formats and synthesize a common format to be used within the geolocation workbench. Utilizing object-oriented techniques a signal class hierarchy was developed consisting of a SIGNAL class and sub-classes of Pulse Descriptor Word and Digital IF signals.

The results of this thesis are a common abstraction for representing signals, and high level design for the Signal Management functions of the Workbench. This abstraction provides access for a broad class of algorithms to access signal data sets. The storage of signal sets in both their raw format and the converted format facilitates the development of geolocation algorithms as well as filtering and signal processing algorithms.

MASTER OF SCIENCE IN COMPUTER SCIENCE

THE DESIGN AND IMPLEMENTATION OF A COMPILER FOR
THE OBJECT-ORIENTED DATA MANIPULATION LANGUAGE
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B.S., Turkish Naval Academy, 1989
Master of Science in Computer Science-December 1995
and
Carlos Martin Barbosa-Lieutenant, United States Navy
B.S., United States Naval Academy, 1989
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Advisors: David K. Hsiao, Department of Computer Science
C. Thomas Wu, Department of Computer Science

Object-oriented relationships, such as inheritance and covering can not be readily incorporated in classic data models. This thesis addresses this problem by the design and implementation of an object-oriented data model (O-ODM), that incorporates the object-oriented paradigm.

A Multimodel and Multilingual Database System called M²DBS has been developed at the Naval Postgraduate School. This system incorporates the classic database data models along with a recently developed object-oriented data model (O-ODM). The problem addressed by this work is to design a new object-oriented data manipulation language (O-ODML) for the O-ODM. The approach is to develop and construct an O-ODML Compiler. Then assimilate the compiler with the Kernel Mapping System (KMS) of the M²DBS.

The result of this thesis is a compiler for the O-ODML of the O-ODM. This O-ODML compiler takes an O-ODM query converts it into a low level intermediate language before translating it into a format that the Real Time Monitor can execute on the M²DBS.

THE OBJECT-ORIENTED DATABASE AND PROCESSING OF
ELECTRONIC WARFARE DATA
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B.S.E., Chung-Cheng Institute of Technology, 1981
Master of Science in Computer Science-December 1995
and
Thomas D. McKenna-Lieutenant Commander, United States Navy
B.S., University of South Carolina, 1980
Master of Science in Computer Science-March 1996
Advisors: David K. Hsiao, Department of Computer Science
C. Thomas Wu, Department of Computer Science

The Electronic Warfare Integrated Reprogramming (EWIR) database is the primary Department of Defense source for technical parametric performance data on noncommunications emitters. It has been identified by the National Air Intelligence Center as difficult to use in its current hierarchical database form. There are two problems addressed by this thesis. First, is an object-oriented EWIR database a superior method for managing complex electronic warfare data collections? Second, is the prototype Object-Oriented Interface (O-OI) developed at the Laboratory for Database System Research in the Naval Postgraduate School capable of supporting a complex object-oriented database such as EWIR?

To answer these questions, a *subset* of the EWIR Object-Oriented Specification developed in a separate thesis is implemented on the O-OI. Using the O-OI Data Definition Language, the object-oriented EWIR database schema and its associated record data are stipulated and loaded to create the live database. Using the O-OI Data Manipulation Language, nine EWIR transactions are elaborated and executed.

The first result of this thesis is the O-OI performs as specified, but requires additional data manipulation and logical control functions to handle complex databases. The minimum additional functions include *Insert, Delete,* and *If-then-else.* The inheritance feature also requires a generalization-to-specialization data retrieval capability. The second result of this thesis is the straightforward data manipulation capability of the object-ori-

ented version of the EWIR database. The object-oriented specification more accurately captures data relationships. The inheritance, path, and object comparison features streamline the linkage of related data, thus simplifying ad hoc query construction.

MISSION PLANNING AND MISSION CONTROL SOFTWARE FOR THE PHOENIX AUTONOMOUS UNDERWATER VEHICLE (AUV): IMPLEMENTATION AND EXPERIMENTAL STUDY
Bradley J. Leonhardt-Lieutenant, United States Navy
B.S., Auburn University, 1989
Master of Science in Computer Science-March 1996
Advisors: Donald P. Brutzman, Undersea Warfare Academic Group
Robert B. McGhee, Department of Computer Science

The Naval Postgraduate School Autonomous Underwater Vehicle (AUV), Phoenix, has a well developed lower level architecture (Execution level) while the upper, Strategic and especially the Tactical, levels need refinement. To be useful in the fleet an easier means of creating mission code for the Strategic level is required. A software architecture needed to be implemented at the Tactical level on-board Phoenix which can accommodate multi-processes, multi-languages, multi-processors and control hard real-time constraints existing at the Execution level. Phoenix also did not have a path replanning capability prior to this thesis.

The approach taken is to provide Phoenix a user-friendly interface for the autogeneration of human-readable mission code and the creation and implementation of a Tactical level control architecture on-board Phoenix to include path replanning. The approach utilizes Rational Behavior Model (RBM) architectural design principles. This thesis focuses on the Officer of the Deck and replanning at the Tactical level, and refinement of the Captain at the Strategic level. While further testing is necessary, Phoenix is now capable of behaving as a truly autonomous vehicle.

Results of this thesis show that nontechnical personnel can generate Prolog code to perform missions onboard Phoenix. Path replanning and obstacle avoidance software are also implemented. Most important this thesis demonstrates successful operation of all three levels of the RBM architecture on-board Phoenix.

CONTROLLED ACCESS PROTECTION IN THE TELESCRIPT™ PROGRAMMING LANGUAGE
Robert Lawrence Marlett-Lieutenant Commander, United States Navy
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Master of Science in Computer Science-September 1996
Advisor: Cynthia E. Irvine, Department of Computer Science
Second Reader: Louis D. Stevens, Department of Computer Science

Research on the ability of the Telescript™ language and execution mechanism to enforce controlled access protection on mobile agents moving in and across distributed computer networks has not been published. Nor has General Magic, the creator of the language, conducted security testing on their product.

This thesis investigates whether the mobile agents and execution mechanism proposed by General Magic in its Telescript™ language meet the Class C2 Controlled Access Protection criteria as promulgated in the Department of Defense Trusted Computer System Evaluation Criteria (TCSEC). This was done by conducting an analysis of the documentation provided by General Magic in their Telescript™ Development Kit (TDK) and Active Web Tools™ (AWT).

The results of this thesis show that the mobile agents and execution mechanism of the Telescript™ language do not meet the criteria for TCSEC Class C2 Controlled Access Protection. In particular, the criteria for object reuse, system architecture, system integrity, security testing and security documentation are not met. However, discretionary access control (DAC) can be enforced using a user-defined security policy and the requirements for identification and authentication (I&A) and audit are satisfied.

MASTER OF SCIENCE IN COMPUTER SCIENCE

DISCRETE ASYNCHRONOUS KALMAN FILTERING OF NAVIGATION DATA FOR THE PHOENIX AUTONOMOUS UNDERWATER VEHICLE

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The Phoenix Autonomous Underwater Vehicle must be able to accurately determine its position at all times. This requires: 1) GPS and differential GPS for surface navigation, 2) short baseline sonar ranging system for submerged navigation, and 3) mathematical modeling of position.

This thesis describes a method of Kalman filtering to merge the GPS, differential GPS, short baseline sonar ranging, and the mathematical model to produce a single state vector of vehicle position and ocean currents. The filter operates in the extended mode for processing the non-linear sonar ranges, and in normal mode for the linear GPS/DGPS data. This required installation of a GPS system and the determination of the different variances and errors between these systems.

Phoenix now has a real time method of position determination using either position measuring system separately or combined. The results of this work have been validated by real world testing of the vehicle at sea, where position estimates accurate to within several meters were obtained.

THE OBJECT-ORIENTED DATABASE AND PROCESSING OF ELECTRONIC WARFARE DATA

Thomas D. McKenna-Lieutenant Commander, United States Navy
B.S., University of South Carolina, 1980
Master of Science in Computer Science-March 1996
and
J. J. Lee-Lieutenant Colonel, Taiwan Army
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Advisors: David K. Hsiao, Department of Computer Science
C. Thomas Wu, Department of Computer Science

The Electronic Warfare Integrated Reprogramming (EWIR) database is the primary Department of Defense source for technical parametric performance data on noncommunications emitters. It has been identified by the National Air Intelligence Center as difficult to use in its current hierarchical database form. There are two problems addressed by this thesis. First, is an object-oriented EWIR database a superior method for managing complex electronic warfare data collections? Second, is the prototype Object-Oriented Interface (O-OI) developed at the Laboratory for Database System Research in the Naval Postgraduate School capable of supporting a complex object-oriented database such as EWIR?

To answer these questions, a *subset* of the EWIR Object-Oriented Specification developed in a separate thesis is implemented on the O-OI. Using the O-OI Data Definition Language, the object-oriented EWIR database schema and its associated record data are stipulated and loaded to create the live database. Using the O-OI Data Manipulation Language, nine EWIR transactions are elaborated and executed.

The first result of this thesis is the O-OI performs as specified, but requires additional data manipulation and logical control functions to handle complex databases. The minimum additional functions include *Insert, Delete,* and *If-then-else*. The inheritance feature also requires a generalization-to-specialization data retrieval capability. The second result of this thesis is the straightforward data manipulation capability of the object-oriented version of the EWIR database. The object-oriented specification more accurately captures data relationships. The inheritance, path, and object comparison features streamline the linkage of related data, thus simplifying ad hoc query construction.

MASTER OF SCIENCE IN COMPUTER SCIENCE

PROTOTYPE SUPERVISORY AND SUMMARY DISPLAYS FOR THE ADVANCED TOMAHAWK WEAPON CONTROL SYSTEM (ATWCS)

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The problem addressed in this research is the need for supervisory or system summary displays for the Advanced Tomahawk Weapons Control System (ATWCS). These displays are needed to accurately depict the current system state and weapon status in order to aid strike supervisory personnel in making correct and timely decisions. This research examined the problem in the context of designing a set of graphical displays that extracts information relevant to the strike supervisor from ATWCS and displays it in a manner that allows both rapid and accurate interpretation.

The approach used to solve the problem progressed in four distinct phases. The first phase, Requirements Analysis, consisted of gathering system requirements through interviews with U.S. Navy officers who have experience as strike warfare supervisors. In the second phase, an initial design was produced using Century Computing's rapid prototyping tool TAE Plus Workbench™. The third phase involved the heuristic and guideline evaluation of the prototype based on accepted user interface design principles and ATWCS user interface requirement specifications. This evaluation produced a second iteration prototype that was used in the final phase, Usability Testing. The prototype was tested by U.S. Navy Officers with Tomahawk strike experience and test results were recorded. Changes were then made to the prototype to correct usability problems discovered by the user testing, yielding a third iteration prototype.

The final result of this research is a set of prototype displays, in both paper and TAE Plus Workbench™ resource file formats, that will be provided to Naval Command, Control, and Ocean Surveillance Center (NCCOSC) Research, Development, Test and Evaluation Division (NRaD) for consideration during system design and implementation.

POPULATING THE SOFTWARE DATABASE

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The cost of software development could be reduced if relevant reusable software components could be retrieved efficiently. The few libraries currently in existence have no standard method for selecting components germane to the intended application. This thesis focuses on the actual formation and population of library components for an improved software library model proposed in [Ref. 1]. This library would provides the codes for users to implement the desired system in CAPS environment.

The work reported here consists of: identifying candidate reusable components from the Booch Ada Library–by manually inspecting over 500 components; converting the components into a CAPS-compatible format based on the Prototyping System Description Language (PSDL) via Ada-PSDL converter program; creating algebraic specifications to match the semantic description of each component manually; and manually organizing the library into a data structure based on the multi-level filtering concept.

This work provides: (1) the base and guidelines for the: (a) criteria for a reusable component, and (b) process of inspecting and importing components into CAPS reusable component library, and (2) 75 reusable components to be released with CAPS 95 and used to test the user interface for retrieval via multi-level filtering. The process of populating reusable components is time intensive due to various manual processes. Inspecting and converting each component sometimes takes up to an hour for each. Current tools available can be rewritten, i.e., the PSDL-Ada converter, to fully automate this process in accordance with the base and guidelines.

MASTER OF SCIENCE IN COMPUTER SCIENCE

SIMULATION AND ANALYSIS OF A WIRELESS MAC PROTOCOL: MACAW
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MACAW (Medium Access Collision Avoidance Wireless) is a new MAC protocol for wireless LANs proposed by Bharghavan et al. [Ref. 2] based on Karn's MACA protocol [Ref.3]. In this thesis the performance characteristics and operational behavior of the protocol are investigated.

The approach taken was to simulate the protocol by OPNET 2.4c of MIL3, Inc. and determine the utilizations and mean delay times of the transmitters under various operational conditions. Also a new performance measure was defined in terms of utilization and mean delay time.

Our investigation has shown that the optimum performance of the MACAW protocol occurs at approximately 50% channel load. We have also shown the importance of the backoff algorithm, and finally, we have shown that carrier sensing dramatically improves the performance of the protocol for high channel loads.

Simulation results showed that decreasing the backoff increase rate by 15% gave twice as good performance results for the small number of transmitting nodes cases. When carrier sensing was introduced to the protocol, dramatic performance increases resulted under heavy loads (60% to 80% channel loads). Carrier sensing also pushed the optimum performance channel load threshold from 50% to 60%.

A TYPE INFERENCE ALGORITHM AND TRANSITION SEMANTICS FOR POLYMORPHIC C
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In an attempt to bring the ML-style type inference to the C programming language, Smith and Volpano developed a type system for a dialect of C, called PolyC [SmV96a] [SmV95b]. PolyC extends C with ML-style polymorphism and a limited form of higher-order function.

Smith and Volpano proved a type soundness theorem that basically says that evaluation of a well-typed PolyC program cannot fail due to a type mismatch. The type soundness proof is based on an operational characterization of a special kind of semantic formulation called a natural semantics. This thesis presents an alternative semantic formulation, called a transition semantics, that could be used in place of the natural semantics to prove type soundness. The primary advantage of the transition semantics is that it eliminates the extra operational level, but the disadvantage is that it consists of many more evaluation rules than the natural semantics. Thus it is unclear whether it is a suitable alternative to the two-level approach of Smith and Volpano.

Further, the thesis gives the first full type inference algorithm for the type system of PolyC. Despite implicit variable dereferencing found in PolyC, the algorithm turns out to be a rather straightforward extension of Damas and Milner's algorithm *W* for functional languages [DaM82]. The algorithm has been implemented as an attribute grammar in Grammatech's SSL and a complete source code listing is given in the Appendix.

MASTER OF SCIENCE IN COMPUTER SCIENCE

RESEARCH ON MOTION PLANNING OF AUTONOMOUS MOBILE ROBOT

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The path planning algorithm in Yamabico is based on a variation of Dijkstra's algorithm which has time complexity of $O(n^2)$. This algorithm works well in a dynamic environment, but a faster algorithm, called the All-Pairs Minimum Cost Paths algorithm, works even faster, $O(1)$, in the case of a static environment.

The computational complexity of the All-Pairs algorithm is $O(n^3)$, but if we know all pairs in advance, that is, the environment is static, we can preprocess them in advance, and use table lookup instead of Dijkstra's algorithm. Thus, we implemented a table lookup version for the static case, and kept Dijkstra's algorithm for the dynamic case. This results in both speed and flexibility.

This thesis also investigated the Linear Fitting Algorithm for Sonar testing. Range and angle data, from sonar, was fit to a straight line, giving resolution of 1 to 2.5 cm when the robot is within 100 to 150 cm of the line.

A REAL-TIME IMAGE UNDERSTANDING SYSTEM FOR AN AUTONOMOUS ROBOT

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Yamabico-11 is an autonomous mobile robot used as a research platform with one area in image understanding. Previous work focused on edge detection analysis on a Silicon Graphics Iris (SGI) workstation with no method for implementation on the robot. *Yamabico*-11 does not have an on-board image processing capability to detect straight edges in a grayscale image and a method for allowing the user to analyze the data.

The approach taken for system development is partly based on edge extraction and line fitting algorithms of [PET92] with a 3-D geometric model of the robot's world [STE92]. Image grabbing routines of [KIS95] were used to capture images with the robot's digital output camera and processed using image understanding routines developed for a SGI workstation. The routines were modified and ported onto the robot.

The new method of edge extraction produces less ambient noise and more continuous vertical line segments in the gradient image which enhances pattern matching analysis of the image. *Yamabico*-11.'s computer system can capture an image with a resolution of 739 x 484 active picture elements. Edge detection analysis is performed on the robot which generates a list structure of edges and stored in the robot's memory for user analysis.

MASTER OF SCIENCE IN COMPUTER SCIENCE

REACTIVATION OF THE RELATIONAL INTERFACE IN M²DBMS AND
IMPLEMENTATION OF THE EWIR DATABASE
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Second Reader: David K. Hsiao, Department of Computer Science

The primary Department of Defense source for technical parametric performance data on non-communications emitters is the Electronic Warfare Reprogramming Database (EWIRDB). Data representation in the EWIRDB is via disjointed parametric tree models which are implementation oriented. These parametric trees obscure the intended semantics and representation of the data, making the database difficult to use and understand. The problem addressed by this thesis is to determine if the relational model and the relational interface of the Multimodel and Multilingual Database System (M²DBMS) in the Laboratory for Database Systems Research at the Naval Postgraduate School is capable of supporting a representative subset of the EWIRDB.

We implemented a representative portion of the EWIR database on the relational interface of the M²DBMS. In order to accomplish this the relational interface was reactivated and returned to its original operational state and fully tested to determine its capabilities. In addition, the schema and an instance of a relational EWIR data model must be developed for implementation.

The relational interface was successfully returned to its original operational state. Significant limitations in the interface's ability to process queries were discovered, however, in that the system can not query schema of greater than four relations.

DESIGN AND IMPLEMENTATION OF REAL-TIME MONITOR
FOR THE OBJECT-ORIENTED INTERFACE
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B.S., Turkish Naval Academy, 1989
Master of Science in Computer Science-December 1995
Advisors: David K. Hsiao, Department of Computer Science
C. Thomas Wu, Department of Computer Science

In a stand-alone database management system (DBMS), one of the key components is the real-time monitor (RTM) which handles database accesses and responses at run time. In the Multimodel, Multilingual and Multibackend Database Management System (M³DBMS) developed at the Laboratory for Database System Research in the Naval Postgraduate School, there is also the need of a RTM in order to link a specific Data Model and Data Language Interface to the Kernel DBMS. The problem addressed by this thesis is to design and implement a RTM for the Object-Oriented Interface to M³DBMS.

In this interface each object-oriented (OO) query is converted into the equivalent Attribute-Based Data Language (ABDL) queries. However, due to the complexity of the OO operations there is no way to produce these ABDL queries in complete and executable forms. Much of the information needed for the completion and execution of the ABDL queries is provided by the previous ABDL queries. The approach was to develop a RTM which oversees the execution of previous ABDL queries, receives the intermediate results from these queries, and completes the subsequent ABDL queries for execution in the Kernel.

The result of this thesis is a RTM which executes the OO query as directed by the compiler of object-oriented data manipulation language (OODML). Once the OO query is parsed by the OODML compiler, it is transformed into the equivalent ABDL queries and a series of pseudocode in compliance with the protocol between the OODML compiler and the RTM. The RTM executes the operations specified by the pseudocode by

using its built-in functions. However, for the execution of the ABDL queries, it communicates with the Kernel DBMS.

FILE TRANSFER WITH SNR HIGH-SPEED TRANSPORT PROTOCOL
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To validate SNR as a high speed transport protocol, efficient means of transferring large data files are required. The problem is that no file transfer program is currently implemented for SNR. The SNR protocol was described in IEEE Transactions on Communications 91 Vol. 38 #11.

The approach taken was to modify the Trivial File Transfer Protocol (TFTP) and use it with the SNR Receiver and Transmitter implementations in both the FDDI and Ethernet LANs. The program was developed on top of the IP layer in the UNIX operating system using the C programming language. The UNIX system features that were adopted for this implementation were multitasking, shared memory, raw sockets and process control. This required overcoming the problems as signal loss, shared memory size, conflicts among the raw sockets and network interface configuration in an IP host.

The results were a fully functioning TFTP code for a modified SNR Transmitter and Receiver code and a new scheme in transferring files with SNR. An artifact of this thesis was that both client and server were single CPU running eleven processes each for file transfers. Due to this constraint, a large amount of latency in file transfer times, compared to Internet Protocol FTP, was observed.

SIMULATION-BASED VALIDATION OF NAVIGATION FILTER SOFTWARE
FOR A SHALLOW WATER AUV NAVIGATION SYSTEM (SANS)
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Navigation filter software is currently being developed for an inertial navigation system without rotating gyros. This system shall replace the navigation system that is currently used in the Phoenix Autonomous Underwater Vehicle of the Naval Postgraduate School. The filter combines acceleration sensors, angular rate sensors, a water speed sensor, a magnetic compass and a GPS system. The harmonization of the sensors is performed by gain matrices. The filter code must be tested for correctness and evaluated, and optimal values for the gain matrices must be found. Both factors directly influence the accuracy of the computed positions, and thus the quality of AUV navigation.

In this thesis, the Kalman filter code is tested by experimentation with a simulation of a submarine. Two versions of the code are available, both written in LISP and C++. Test runs are performed in different simulated sea-states (water current), with and without noise added to the sensors, and with different values for the gain matrices.

Based on the experiments, the Kalman filter code seems to be correct and stable. Noise is the most important determinant of the filter performance. The results can be optimized by careful fine tuning of the gain matrices.

MASTER OF SCIENCE IN COMPUTER SCIENCE

MOUNTING HUMAN ENTITIES TO CONTROL AND INTERACT WITH NETWORKED SHIP ENTITIES IN A VIRTUAL ENVIRONMENT

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This thesis research addresses the problem of mounting human entities to other nonhuman entities in the virtual environment. Previous human entities were exercised as individual entities in the virtual environment. Yet there are many applications (i.e., shipboard damage control, amphibious landings, helicopter vertical assaults) where human entities need to mount other vehicles within the virtual environment.

The approach taken was to re-engineer the Naval Postgraduate School's Shiphandling Training Simulator (SHIPSIM) and Damage Control Virtual Environment Trainer (DC VET) onto a common virtual environment system (NPSNET). Using a modified potentially visible set algorithm, a ship hydrodynamics model, and a simple data PDU network packet, NPSNET human entities were given the capability to mount ship vehicles. Additionally, a control panel and voice recognition were added to allow the human entities to control and maneuver the ship vehicles in the virtual environment.

As a result of this thesis, NPSNET human entities can mount ship vehicles, move about the ship, and interact with the ship's internal objects (i.e., doors, valves, etc.) all while the ship moves within the virtual environment. This technology opens a new paradigm for simulation designers, where users of virtual environment systems can participate as human entities and interact (i.e., mount, control, and maneuver) with other inanimate vehicles as we do in the real world.

A RAPIDLY RECONFIGURABLE, APPLICATION LAYER, VIRTUAL ENVIRONMENT NETWORK PROTOCOL

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The current Distributed Interactive Simulations (DIS) Protocol has a limited ability to support real-time, simulated engagements of more than 1000 entities because of its excessive use of network resources. It also lacks the extensibility to add new protocol data units to support new simulation requirements. To solve these problems it is necessary to design and implement a rapidly reconfigurable network protocol that can be easily changed and distributed to all entities in a large-scale simulation. This protocol must be highly flexible and allow for the optimization of data content during execution.

The approach used was to design and build a rapidly reconfigurable network protocol and the tools necessary to use it. This was accomplished in four phases. First, a protocol using the concepts of Self-defined Messages with Multiple Presentations was developed. Second, a formal grammar to describe the protocol was designed. Third, an existing protocol development tool, the DIS Protocol Support Utility, was modified to use the new protocol and grammar. Fourth, the protocol was tested to determine its effect on network resource utilization.

As a result of this effort, a network protocol for distributed simulations that can be optimized at run-time and easily modified has been developed. Testing shows that the protocol can reduce the network bandwidth necessary for a large-scale distributed simulation by up to 70%.

MASTER OF SCIENCE IN COMPUTER SCIENCE

INTERNETWORKING: MULTICAST AND ATM NETWORK PREREQUISITES FOR DISTANCE LEARNING

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The Internet, the World Wide Web and the Multicast Backbone (MBone) have been used in a variety of ways for distance learning. Video TeleConferencing (VTC) classrooms have obvious value and utility but they are limited to communicate with only a small number of similar VTC facilities. We are most interested in open solutions which take advantage of the global Internet. Therefore the problem addressed by this thesis is to evaluate the specific benefits and drawbacks of Internet technologies in support of distance learning.

This thesis includes a detailed examination of MBone, Asynchronous Transfer Mode (ATM) and the Distributed Interactive Simulation (DIS) protocol from the perspective of distance learning.

One result we found is that MBone can be used successfully for distance learning purposes despite common constraints of limited (128 Kbps) bandwidth. A further result is that an MBone classroom can be 42% as expensive as a VTC classroom if an *SGI Indy* is used and 12% as expensive as a VTC classroom if a PC is used in the classroom. Consequently many schools can afford Internet-based distance learning using the solutions presented in this thesis even though they cannot afford VTC rooms.

DESIGN AND EVALUATION OF AN INTEGRATED, SELF-CONTAINED GPS/ INS SHALLOW-WATER AUV NAVIGATION SYSTEM (SANS)

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The main problem addressed by this research is to find an alternative to the use of large and/or expensive equipment required by conventional navigation systems to accurately determine the position of an Autonomous Underwater Vehicle (AUV) during all phases of an underwater search or mapping mission.

The approach taken was to advance an existing integrated navigation system prototype which combines Global Positioning System (GPS), Inertial Measurement Unit (IMU), water speed, and heading information using Kalman filtering techniques. The hardware and software architecture of the prototype system were advanced to a level such that it is completely self-contained in a relatively small, lightweight package capable of on-board processing of sensor data and outputting updated position fixes at a rate of 10 Hz; an improvement from the 5 Hz rate delivered by the prototype. The major changes to the preceding prototype implemented by this research were to install an on-board processor to locally process sensor outputs, and improve upon the analog filter and voltage regulation circuitry.

Preliminary test results indicate the newly designed SANS provides a 100% performance improvement over the previous prototype. It now delivers a 10 Hz update rate, and increased accuracy due to the improved analog filter and the higher sampling rate provided by the processor.

MASTER OF SCIENCE IN COMPUTER SCIENCE

THE ACTIVATION AND TESTING OF THE NETWORK CODASYL-DML INTERFACE OF THE M2DBMS USING THE EWIR DATABASE

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The Electronic Warfare Integrated Reprogramming Database (EWIRDB) is the primary Department of Defense source for technical parametric performance data on noncommunications emitters. A problem of the EWIRDB is that the data are represented in disjoint parametric tree models that are implementation oriented. The parametric tree with its deceptive hierarchical structure, provides a poor modeling construct that obscures the intended semantics and representation of the data, thus making the database difficult to use and understand from a users perspective. The problem addressed by this thesis is to determine if the network model and the network interface of the Multi-Lingual, Multi-Model Database Management System (M²DBMS) in the Laboratory for Database Systems Research at the Naval Postgraduate School is capable of supporting a representative subset of the EWIRDB.

The primary goal of this thesis is to implement a representative portion of the EWIR database on the network interface of the M²DBMS. In order to accomplish this goal, the following issues must be addressed: First, the network interface must be activated and returned to its original operational state; second, the network interface must be tested to determine its capabilities and limitations; and last, the design and specification of a network EWIR data model must be completed prior to its implementation.

We successfully reactivated the network interface to its original operational state. However, testing revealed significant limitations of the network interface. Due to these limitations, only the data definition portion of our proposed design was fully implemented.

SOFTWARE SYSTEM REQUIREMENTS FOR THE ARMY TACTICAL MISSILE SYSTEM (ATACMS) END-TO-END SYSTEM USING THE COMPUTER AIDED PROTOTYPING SYSTEM(CAPS) MULTI-FILE APPROACH

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The Department of Defense (DoD) is seeking software system requirements for the Army Tactical Missile System (ATACMS) End-to-End System, which comprises both ATACMS and all sensors, links, and command centers which enable integration across system and service boundaries. The complexity, multiple interfaces, and joint nature of planned ATACMS operations demands accurate specification of software system requirements. DoD also desires automated tools capable of developing rapid prototypes to assist in system definition and reduce system risk.

The goals of this thesis are to provide a rigorous model which can be utilized to validate current specifica-

tions, and, to demonstrate CAPS on a large scale project. Accomplishment of these two would provide a needed corroboration of the ATACMS specification, as well as move CAPS out of the purely academic environment.

The result of this thesis is mixed. Due to a paucity of data from which to derive the requirements, the model is generic in nature and is in need of significant customer evaluation, which is not forthcoming. However, CAPS demonstrated its fundamental concept within the bounds of the project, with refinements in code generation, interface, and graphics either incorporated or identified. CAPS is ready for use on an actual project by an experienced team of systems analysts.

A METHODOLOGY FOR EVALUATING THE CAPABILITY OF THE BRADLEY 25MM CANNON TO ENGAGE AND DEFEAT PIONEER CLASS UNMANNED AERIAL VEHICLES.

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Unmanned Aerial Vehicles (UAVs) represent a serious threat to forward deployed forces of the United States Army. The defense against such threats is currently provided primarily by the Bradley Stinger Fighting Vehicle (BSFV). The problem addressed is how to evaluate the effectiveness of the BSFV against a UAV. This thesis develops a computer simulation methodology for modeling the capability of a gun system to engage a UAV. Specifically, a review is made of the BSFV, BSFV 25mm Ammunition, and UAVs. These reviews formed the basis for a computer simulation, coded in Common Lisp Object System (CLOS), modeling the characteristics of three objects: a Projectile, a Launcher and a UAV. Although assumptions were made to simplify the model, simulation runs demonstrated that the rate of fire and aiming system used for launching projectiles resulted in one or more hits in 125 out of 154 engagement sequences. These engagement sequences were against a UAV flying at constant speed and altitude in crossing and inbound/outbound flight profiles. While all data used in this simulation were unclassified, the methodology presented could be used for further classified study, potentially producing a lower cost means for determining the effectiveness of air defense weapons against UAV threats.

A GRAPHIC USER INTERFACE FOR RAPID INTEGRATION OF STEGANOGRAPHY SOFTWARE

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Steganography is a method an individual uses to secretly communicate, whereby the transmitting agent hides a message within some medium, so that only an intended recipient can detect the message's presence. Researchers who apply this methodology to digital imagery currently have no X Windows-based graphic user interface software package through which they may aggregate, test, and demonstrate their steganography programs. Such a package would contain features to encode data to and extract data from digital imagery, convert the files to other graphic file formats, display imagery, and offer some utility to analyze change between unencoded original images and their encoded equivalent. The steganography software development package presented in this thesis, named Steganography Toolbox, satisfies these requirements. It provides the above described features, plus the ability to delete unneeded files, all in an X Windows graphic user interface. It permits the user, who writes a separately executable steganography program, to attach it to the graphic interface with little additional programming effort. The thesis describes a method to create a menu-selected dialog box containing the necessary widgets, which invokes the desired program through a *system()* call. The thesis includes Steganography Toolbox's structured design documentation, from system requirements to process specifications. The thesis also describes how requirements-based software tests were performed on each module to verify proper function and error-handling.